

## **Preventing Spatial Filter Pinhole Closure with the Pinholes Required to Control Beam Breakup for the NIF**

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Closure of spatial filter pinholes has been a problem since spatial filters were first used on high power lasers. NIF uses longer pulselengths ( $> 20$  ns) and tighter pinholes ( $\pm 100 \mu\text{rad}$ ) than previous laser systems, making the problem worse. Furthermore, the temporal pulse shape and beam-to-beam power balance requirements will be tighter than for previous lasers, allowing only a few percent transmission loss from partial pinhole closure. Pinhole transmission problems can also affect beam uniformity, because steering introduced near the pinhole can redistribute energy in the near field of the beam, leading to an unacceptable increase in beam modulation. A detailed examination of the pinhole closure phenomenon is required to understand the physics and eliminate its effects on laser performance.

To maintain low beam modulation at or near NIF redline operating conditions, sufficiently small pinholes are required in the multipass cavity spatial filter (CSF) to protect the final amplifier stages, and in the transport spatial filter (TSF) to protect the transport mirrors and frequency converter. Spatial filtering limits nonlinear ripple growth which results from the intensity dependent nonlinear phase shift,  $\Delta B$ , accumulated in beam paths between consecutive filtering stages. Beamlet measurements show that  $\pm 130$  and  $\pm 100 \mu\text{r}$  pinholes in the CSF and TSF allow the booster section to operate at a  $\Delta B$  of 2.2 without degrading output beam quality. At NIF maximum output conditions of  $\Delta B < 1.7$ , this provides a sufficient margin against filamentation damage due to operator mistake and/or beam uniformity problems. Larger pinholes reduce the filamentation margin significantly, lowering the safe operating regime of the laser.

Beamlet far-field data indicate a pinhole edge-irradiation in the TSF of  $> 10^{12}$  W/cm<sup>2</sup>, which can ablate a sufficiently dense plasma into the pinhole opening to close it. Previous pinhole closure experiments<sup>1-3</sup> report closure velocities for the standard, washer-type pinholes that range from  $1 \times 10^7$  to  $5 \times 10^7$  cm/sec. The slowest of these

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would completely close a  $\pm 130 \mu\text{rad}$  pinhole in the NIF CSF (pinhole radius = 1.5 mm) well before the end of a 20 ns pulse.

Several pinhole geometries have been suggested to delay appearance of closure conditions. One of the most promising, a tapered conical pinhole with the smaller end at the focal plane, increases the angle of incidence to the surface normal for the intercepted radiation to decrease fluence on the absorbing surface. Optimum cone angles nearly match the cone angle of the spatial filter lens. The high angle of incidence decreases absorption in the plasma ablating from the surface, and refracts the unwanted energy out of the acceptance angle of the beam rather than absorbing it. Measurements<sup>1</sup> show an effective closure time about three times longer than for an equivalent washer-type pinhole.

LASNEX<sup>4</sup> calculations also show longer closure delays for higher atomic weight materials, about 2x slower for Au than organic polymers (C-H). However, experiments to date have not shown significant differences<sup>1,2</sup>. We plan experiments to further investigate material and geometry differences.

#### References

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